NON-PROVISIONAL PATENT APPLICATION

TITLE: LOWER TURRET BEARING SYSTEM FOR FPSO

INVENTORS: CHARLES L. GARNERO AND L. TERRY BOATMAN

BACKGROUND OF THE INVENTION

CROSS REFERENCE RELATED TO APPLICATION

This application is based upon and claims the priority of U.S. Provisional Application 60/412, 413 filed September 19, 2002.

1. Field of the Invention

This invention relates generally to Floating Production Storage and Offloading vessels (FSO's and FPSO's). In particular, this invention relates to large diameter mooring turrets requiring a lower bearing system that will have high reliability and can be constructed at lower cost as a result of a new configuration of the bearing arrangement.

2. Description of the Prior Art

Numerous references to turret lower bearings are known in the prior art. Two of the more recent patents are Braud, U.S. 5,913,279, and Boatman, U.S. 5,306,186. Both of these patents illustrate versions of adjustable and self-aligning lower bearings.

3. Identification of Objects of the Invention

A primary object of this invention is to provide an improved lower bearing arrangement that is highly reliable and of lower cost than that of prior lower bearing arrangements.

Another object is to provide a lower bearing arrangement that operates in combination with an upper bearing where the upper bearing is not supported by elastomeric or metal springs.

Another object of the invention is to provide an improved lower bearing arrangement that operates in combination with an upper bearing wherein the upper bearing is supported by elastomeric or metal springs.

Another object of the invention is to provide a lower, radial bearing arrangement that operates in combination with a rail and wheel type upper bearing.

Another object of the invention is to provide a lower bearing arrangement where the low friction material of the sliding surface of the bearings units can be replaced while the vessel remains moored at its offshore location.

Another object of the invention is to provide a lower bearing arrangement where a radial clearance is provided for the purpose of reducing sliding wear of the low friction material of the surface of the bearing unit.

Another object of the invention is to provide a lower bearing arrangement where the low friction material is thick enough such that the thickness provides sufficient wear life even if the bearing support foundation is installed with inherent out-of-roundness as a result of unavoidable shipyard manufacturing dimensional tolerances.

Another object of the invention is to provide a lower bearing arrangement that can be constructed within a turret moonpool without costly machining of the lower bearing support structure attached to the vessel hull structure.

SUMMARY OF THE INVENTION

The objects identified above along with other features and advantages of the invention are embodied in an improved radial bearing arrangement for a turret mooring arrangement in which a turret is rotationally supported on a vessel. The turret is placed within a moonpool

tube with rotational support between the turret and the vessel provided by an axial support bearing and the improved radial bearing arrangement of the invention.

The improved radial bearing arrangement utilizes an inner ring with a cylindrical bearing surface secured about an exterior portion of the turret. The inner ring has an outer surface with an outer diameter. A plurality of separate radial bearing assemblies are arranged in an outer ring inwardly of the moonpool tube. Each of the assemblies has a pad of low friction material with an inwardly facing surface such that the inwardly facing surfaces collectively define a segmented substantially cylindrically shaped surface having an inner diameter.

The inner diameter of the cylindrically shaped surface defined by the pads of the radial bearing assemblies of the moonpool tube is greater than the outer diameter of the inner ring of the turret, such that when the turret is substantially axially aligned with the moonpool tube, a radial gap exists between each of the inward facing low friction material surfaces of the pads and the inner bearing surface ring of the turret.

A mounting arrangement for the radial bearing arrangements and the radial gap allows replacement of the bearing elements when the vessel is moored by the turret in offshore waters.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is illustrated by the attached drawings of which:

Figure 1 is a cross-sectional elevation view through an internal turret and vessel;

Figure 2 is an enlarged view of the chain table area at the bottom end of the turret; and

Figure 3 is an enlarged elevation view of the area at the lower bearing.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

The invention is embodied in a lower bearing arrangement for a turret transfer system of a FPSO as illustrated in the figures where reference numbers are assigned to the following elements:

1	FPSO vessel hull
2	Chain table
3	Chain support
4	Bearing surface ring
5	Low friction material
6	Fastener
7	Radial gap
8	Lifting eye
9	Bearing bracket
10	Attachment device
11	Bearing support ring
12	Hull bracing
13	Moonpool tube
14	Lower bearing unit
15	Upper bearing
16	Mooring turret
17	Risers
18	Riser guide tube
19	Corrosion resistant surface
20	Inside diameter
21	Anchor leg

Detailed Description

Figure 1 illustrates a cross sectional elevation view through an internal turret wherein mooring turret 16 is rotatably supported by upper bearing 15 within vessel hull 1. Multiple lower bearing units 14 spread about the inner surface of the moonpool tube 13 provide radial support of turret 16 at the outside diameter of chain table 2. The turret 16 is of the arrangement as illustrated in Figure 1 and as shown in more detail in corresponding U.S. Application Serial No. 10/325,122 filed on December 19, 2002 and incorporated by reference herein. The shape of the turret is not limited to that of Figure 1, but may be a typical tube shape turret or a turret of other shapes.

The preferred embodiment of the upper bearing 15 comprises a rail and wheel type upper bearing such as manufactured by Hydralift Amclyde Incorporated, but the present

invention may also be used in combination with an upper bearing of the multiple row slewing ring bearing type. The upper axial bearing arrangement is also shown in the above mentioned U.S. Application Serial No. 10/325,122. Anchor legs 21 attach to chain table 2 by means of chain supports 3. Fluids and gases are transferred to and from the FPSO vessel through risers 17 that pass through chain table 2 by means of riser guide tubes 18.

Figure 2 shows an enlarged view of chain table 2 at the bottom end of mooring turret 16. Bearing surface ring 4 is a continuous ring encircling and rigidly attached to chain table 2. A plurality of lower bearing units 14 are secured in a ring secured to the inside of moonpool tube 3 with each of the units 14 facing the bearing surface ring 4.

Figure 3 is an enlarged elevation view of the area at lower bearing unit 14 that shows a section detail of the preferred embodiment of a lower bearing unit 14. Each lower bearing unit 14 includes low friction material pad 5, bearing bracket 9, and attachment device 10. Corrosion resistant surface 19, preferably of INCONEL™, or stainless steel, is attached to bearing surface ring 4 to provide a surface on which the pads 5 of low friction material, such as ORKOT™ or similar non- metallic material, may slide with low friction and minimal wear. The trademark ORKOT is a mark of ORKOT Marine Bearings that are manufactured by impregnating cloths of fibers with thermosetting resines. Such materials have exceptional wear resistant properties with or without lubrication. Radial gap 7 provides a predetermined clearance between a low friction material pad 5 and surface 19 under normal operation and rotation of the FPSO around geostationary turret 16. Flexure of turret 16 in addition to unavoidable misalignment of upper bearing 15 with lower bearing units 14 causes clearance gap 7 to increase and decrease during operations with only occasional contact between surface 19 and low friction material pad 5. Only when sea conditions become more severe does contact and heavy sliding action take place between surface 19 and low friction material 5.

Low friction material 5 is attached to bearing bracket 9 by fasteners 6. Bearing brackets 9 are arc segments disposed outwardly and spaced around bearing surface ring 4. Attachment device 10 locks each bearing bracket 9 to bearing support ring 11. Lifting eyes 8 are provided for lifting each attachment 10 and bearing support ring 11. Bearing support ring 11 is rigidly attached, preferably by welding, to hull bracing 12 outside of moonpool tube 13. Inside radius 20 is gas flame cut and hand trimmed within a suitable radial accuracy of about ± 3 to 5 millimeters deviation from a true circle.

A sufficient thickness, such as from 25 to 60 millimeters, of low friction material 5 provides a wear allowance to compensate for small variances in radial position of lower bearing units 14 in addition to normal wear incurred over the service life of mooring turret 16.

Each bearing low friction material pad 5 and bearing bracket 9 can be removed from bearing support ring 11 while the turret is secured to a sea bottom by anchor legs 21. The procedure is enabled because of the presence of gap 7. The attachment device 10 is released from bearing support ring 11, and the pad and bearing bracket 9 is lifted with lifting eyes 8 such that attached pad 5 and bearing bracket 9 are lifted together above ring 11. A worn pad 5 can be removed at that point by removing fasteners 9. A new pad 5 can be substituted for a worn pad. The bracket 9 and new pad 5 are then lowered by lifting eye 8, and the attachment device 10 secures the bearing members 5 and 9 again to bearing support ring 11.